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DO ANTHROPOMETRIC MEASUREMENTS OF THE HAND IMPACT THE HISTOLOGICAL STRUCTURE OF THE HUMAN MEDIAN NERVE AT THE LEVEL OF THE CARPAL TUNNEL?

Abstract: *Do anthropometric measurements of the hand impact the histological structure of the human median nerve at the level of the carpal tunnel?*

Introduction: The literature lacks data on the histological structure of the median nerve on the level of the carpal tunnel, and its possible correlations with the anthropometric measurements of the hand.

Aim: The aim of this study was to assess the anthropometric measurements of human cadaver hands and their median nerves histological structure and whether a correlation existed between these two.

Material & Methods: This study has been conducted using cadavers stored in a 10% solution of formaldehyde at the Department of Anatomy of the Jagiellonian University Medical College (JUMC) and cadavers from the Department of Forensic Medicine JUMC. Before dissection anthropometric measurements were carried out. After dissection the median nerves were stained with haematoxylin and eosin and histological slides were prepared. These were later photographed (16 × magnification) and analysed using ImageJ software.

Results: The studied group comprised 8 women and 22 men (age between 23–92 years). Anthropometric measurements comparison by gender revealed statistically significantly larger CR-CU, MR-MU and TS-ID distances in men then in women. When comparing sides, the cross-sectional area (CSA) of the right median nerve (0.216 ± 0.06 cm^2) was statistically significantly larger ($p = 0.017$) then the CSA of the left median nerve (0.173 ± 0.05 cm^2). No correlation was noted between the anthropometric and histological measurements obtained in this study.

Conclusions: Anthropometric measurements of the hand do not impact the histological structure of the human median nerve at the level of the carpal tunnel. Nerve bundles of the median nerve, at the level of the carpal tunnel, display no particular type of arrangement.

Key words: median nerve, nerve bundles, anthropometric measurements, carpal tunnel

INTRODUCTION

The carpal tunnel, located on the palmar surface of the wrist, contains the median nerve, four tendons of the flexor digitorum superficialis, four tendons of the flexor digitorum profundus, and the tendon of the flexor pollicis longus [1].

The median nerve is a mixed motor and sensory nerve [2]. It descends beneath the flexor digitorum superficialis, lying on the flexor digitorum profundus in the forearm, within 5 cm of the transverse carpal ligament and then it becomes more superficial, situated between the tendons of the flexor digitorum superficialis and the flexor carpi radialis [3]. It lies behind and radial to the side of the palmaris longus tendon just before entering the carpal tunnel [3].

The median nerve normally divides into six branches at the distal terminus of the flexor retinaculum [1–3]. These include the recurrent motor branch innervating the opponens pollicis, abductor pollicis brevis and the flexor pollicis brevis [2].

Since the nerve passes through the narrow carpal tunnel, which is crowded inside and outside, by a series of structures, it is therefore important for clinicians to recognize the frequency and multiplicity of the variations within the region of the wrist [4, 5].

The literature lacks data on the histological structure of the median nerve on the level of the carpal tunnel, and its possible correlations with the anthropometric measurements of the hand. This might be due to the fact that most studies focusing on the median nerve are conducted during surgery or by using ultrasound or magnetic resonance imaging.

The first aim of this study was to assess the anthropometric measurements of human cadaver hands and their median nerves histological structure. The second aim was to determine whether a correlation existed between these measurements.

MATERIALS AND METHODS

This study has been conducted using cadavers stored in a 10% solution of formaldehyde at the Department of Anatomy (Jagiellonian University Medical College) as well as cadavers from the Department of Forensic Medicine (Jagiellonian University Medical College). The studied group comprised 8 women and 22 men (age span between 23 and 92 years). A total of 60 median nerves was acquired.

There were no restrictions as to gender or age concerning inclusion into the study. Exclusion criteria included extensive damage to the median nerve preventing proper sample acquisition.

The research protocol was approved by the Jagiellonian University Ethics Committee (registry KBET/209/B/2002).

Anthropometric points and measurements

Before dissection, anthropometric measurements of the hand were carried out, using a digital caliper (Limit, Poland). The following anthropometric points were used:

— Carpale radiale (CR) — situated on the lateral margin of the hand, on the level of the radiocarpal joint;
— Carpale ulnare (CU) — situated on the medial margin of the hand, on the level of the ulnocarpal joint;
— Metacarpale radiale (MR) — situated on the lateral margin of the hand, in the place of the biggest prominence of the head of the second metacarpal;
— Metacarpale ulnare (MU) — situated on the medial margin of the hand, in the place of the biggest prominence of the head of the fifth metacarpal.

For this study, apart from the standard anthropometric points, additional points were set:

— The tuberculum of the scaphoid bone (TS);
— Interdigitalis II–III (ID) — situated halfway between the bases of the second and third fingers.

The following measurements were made:

— The width of the wrist — the distance between the CR and the CU;
— The width of the metacarpus — the distance between the MR and the MU;
— The distance between the TS and the ID.

Each measurement phase was carefully photographed using a digital camera [6].

Dissection technique

The incision was made starting at the distal 1/3 of the forearm, continuing between the tendon of the flexor carpi radialis and the tendon of the palmaris longus muscle, along the thumb flexion line. After dissecting the skin and the subcutaneous tissue, the median nerve was exposed and the flexor retinaculum was cut on the ulnar side. Next the median nerve was dissected (in or above the carpal tunnel). The existing incision was closed using a running intradermal suture.

Preparing histological slides

First a fragment of the main stem of the median nerve was excised (between the distal 1/3 part of the forearm to the site where the common palmar digital nerves branch out).

This fragment of the median nerve was then placed in a glass container with a 10% solution of formaldehyde (pH 7.4). After 2 to 5 days a part of the main stem of the median nerve was excised (right above the motor branch). Tissues were dehydrated, embedded in paraffin, sectioned at 4μm and stained with hematoxylin & eosin.

Micromorphometry

The number of nerve bundles in the main stem of the median nerve was assessed using light microscopy (100x magnification). Next, each main stem cross-section was photographed (16x magnification) and the images were analyzed using Java ImageJ (version 1.46d) developed by Wayne Rasband (National Institute of Health) [7]. The cross-sectional area, transverse and longitudinal dimensions and the number of nerve bundles in the median nerve were calculated.

Statistical analysis

Statistical analysis was conducted using computer software Statistica 10.0 PL by StatSoft Poland. To analyze the data, elements of descriptive statistics were used (mean, standard deviation, percentage distribution, minimum value, maximum value). To assess differences between groups the Students' t-test was used. The significance level was set at $p < 0.05$.

RESULTS

Anthropometric measurements

The width of the wrist in the whole group varied from 4.50 cm to 6.20 cm (mean 5.43 cm). The width of the metacarpus varied from 6.30 cm to 9.10 cm (mean 7.88 cm). The distance between the TS and the ID varied from 7.40 cm to 11.30 cm (mean 9.12 cm). The width of the flexor retinaculum (FR) varied from 2.10 cm to 4.20 cm (mean 2.75 cm). The distance between the TS and the point where the motor branch (MB) of the median nerve branched off the median nerve varied from 1.80 cm to 4.50 cm (mean 2.92 cm).

Anthropometric measurements comparison by gender is presented in Table 1. Anthropometric measurements comparison by side did not reveal any statistically significant differences.

Table 1

Anthropometric measurements — comparison by gender

Measurements [cm]	Women		Men		
	Mean	SD	Mean	SD	p-value
CR-CU	5.01	0.47	5.58	0.29	< 0.001
MR-MU	7.31	0.53	8.08	0.46	< 0.001
TS-ID	8.62	1.02	9.3	0.77	0.009
FR width	2.58	0.22	2.81	0.57	0.13
TR-MB distance	2.89	0.25	2.93	0.62	0.82

SD — Standard deviation; CR — Carpale radiale; CU — Carpale ulnare; MR — Metacarpale radiale; MU — Metacarpale ulnare; TS — Scaphoid tuberculum; ID — Interdigitalis II–III

Histological measurements

The cross-sectional area of the median nerve varied from 0.098 cm^2 to 0.36 cm^2 (mean 0.19 cm^2). The longitudinal dimensions varied between 0.40 cm to 0.79 cm (mean 0.59 cm). The transverse dimensions varied between 0.28 cm to 0.79 cm (mean 0.40 cm). The number of nerve bundles in the stem of the median nerve varied from 13 to 38 (mean 24.97). No particular arrangement of median nerve nerve bundles was observed at the level of the carpal tunnel.

Histological measurements comparison by gender did not reveal any statistically significant differences. When comparing sides, the cross-sectional area of the right median nerve (0.216 ± 0.06 cm^2) was statistically significantly larger ($p = 0.017$) then the cross-sectional area of the left median nerve (0.173 ± 0.05 cm^2).

No correlation was noted between the anthropometric and histological measurements obtained in this study.

DISCUSSION

This study presents data on the subject of anthropometric measurements of the human hand and histological measurements and structure of the median nerve, and their possible correlations. To the authors knowledge this is the first study assessing such correlations.

In this study the anthropometric measurements had no impact on the histological measurements of the median nerve. When preparing this study we based on the fact that several authors showed that wrist ratio and wrist circumference can be independent risk factors for carpal tunnel syndrome (CTS) development [8]. Moghtaderi *et al.* [8] revealed that wrist ratio could be an independent risk for CTS development, while wrist circumference might have a protective effect. Boz *et al.* [9] showed that wrist ratio, shape index and digit index were independent risk factors in females, but failed to show statistically any significant difference between male cases and controls in these measurements. There are several other studies that have depicted wrist ratio as the prime suspect in the establishment of CTS [8–10].

The role of wrist ratio in CTS development is not fully understood but several theories pretending to explaining this exist. There may be a potential link between wrist ratio and variations in carpal stenosis in the dynamic and static relationship of structures and median nerve abnormalities [10]. Specific wrist shapes may increase the potential for CTS to develop, because of an increase in repetitive hand movements, making the subject more susceptible to CTS [11].

At the assessed level there was no particular type of nerve bundle arrangement in the median nerve or in its motor branch. This finding is consistent with other studies assessing the cross-sections of other human nerves such as the oculomotor nerve [12].

When comparing sides, the right median nerves had a significantly larger cross-sectional area (on the level of the carpal tunnel), which might be contributed to the fact that the majority of the Polish population is right-handed.

The mean cross-sectional area of the median nerve obtained in our study is significantly larger (0.19 vs. 0.10 cm^2; $p < 0.0001$) than in the study by Yao and Gai [13]. This might relate to anatomic differences in the perceived boundary of the nerve in magnetic resonance imaging. This problem disappears when using computer-assisted histological image analysis [7].

Further studies conducted on larger sample groups, using immunohistochemistry [14, 15], should concentrate on the role of median nerve motor and sensory nerve bundles and their correlations with anthropometric measurements of the hand.

CONCLUSIONS

CR-CU, MR-MU and TS-ID distances are larger in men then in women. Anthropometric measurements of the hand do not impact the histological measurements and structure of the human median nerve at the level of the carpal tunnel.

The number of nerve bundles in the stem of the median nerve varied from 13 to 38. The nerve bundles of the median nerve, at the level of the carpal tunnel, display no particular type of arrangement.

CONFLICT OF INTEREST STATEMENT

None declared.

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